Hawaiian	Japanese	Korean	Vietnamese	White	Hispanic‡
11.7	7.0	–	11.6	14.6	8.9
–	3.3	–	–	5.8	2.7
–	2.1	NA	NA	3.8	2.7
–	0.8	NA	NA	1.5	0.7
10.9	8.7	–	–	9.8	8.0
8.7	7.3	7.6	–	7.4	6.9
12.8	8.5	NA	NA	9.7	7.1
9.1	6.7	NA	NA	6.9	5.2
20.5	30.5	48.9	25.8	10.2	15.3
13.0	15.3	19.1	25.8	4.4	8.0
14.4	17.4	NA	NA	6.1	8.4
12.8	9.3	NA	NA	2.8	4.2
–	13.7	10.4	–	31.7	15.8
–	4.1	–	–	7.8	4.3
–	2.0	NA	NA	5.8	2.8
–	1.2	NA	NA	1.7	0.9

‡Estimates for all cancer sites are rounded to the nearest integer.
¶National Center for Health Statistics, public use data tapes, 1988–1992, is the source for all death rates in this table. Death rates are U.S. mortality rates.
**A dash means that the rate was not calculated for fewer than 25 cases.
NA = data not available.
Source: National Cancer Institute 1996b; National Center for Health Statistics, public use data tapes, 1988–1992.

Esophageal Cancer

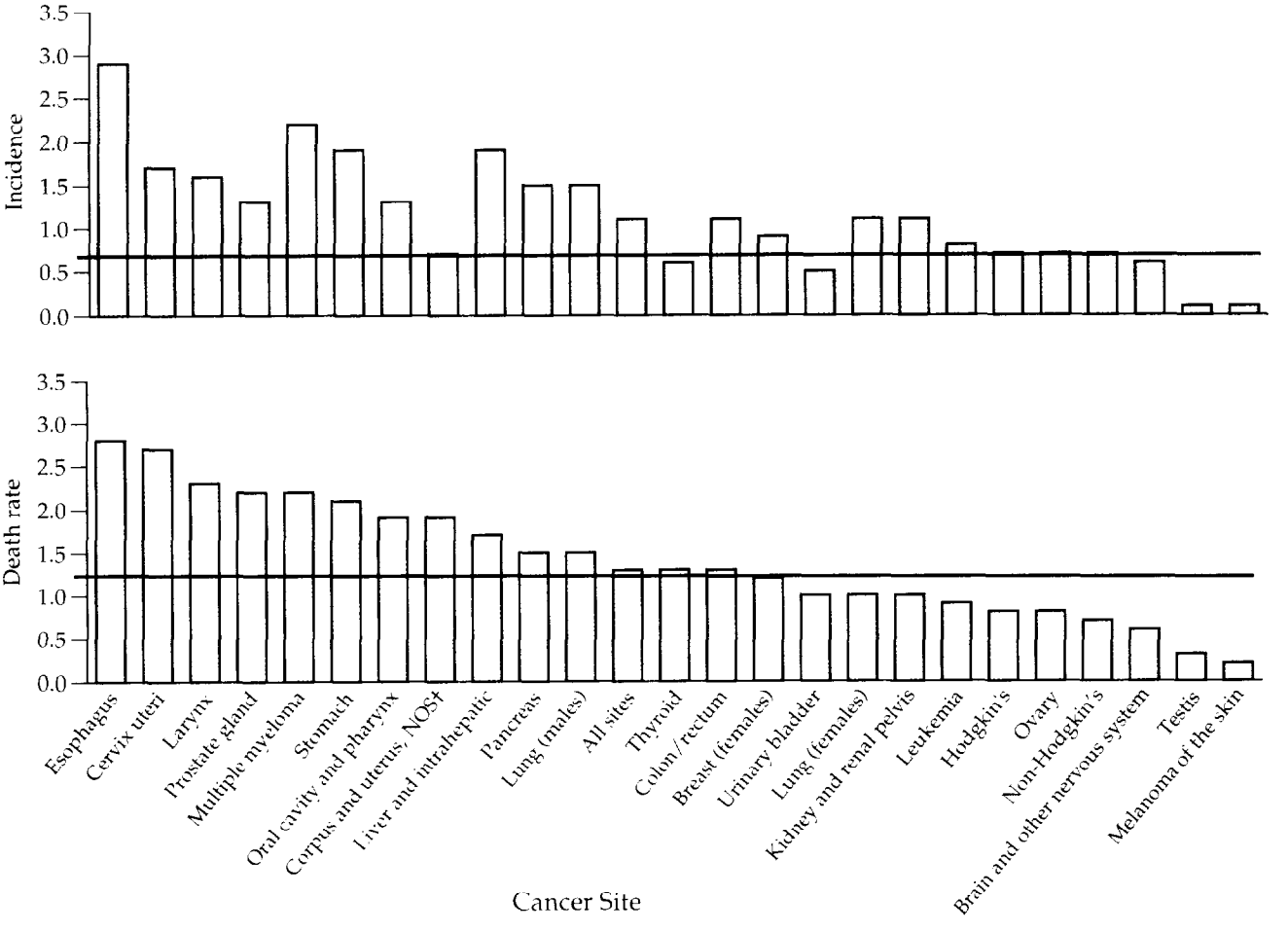
Esophageal cancer incidence and death rates in the United States are highest among African Americans (Tables 2 and 6) (NCI 1996b). To assess potential causes of the high rates of death from esophageal cancer found among African American men, Pottern and colleagues (1981) conducted a case-control study in Washington, D.C. After adjusting the data for alcohol consumption, they found that the relative risk of esophageal cancer among smokers was only marginally higher than among nonsmokers. In a more recent study, the risk for African American men of developing squamous cell carcinoma of the esophagus was significantly elevated for smokers, even after adjusting statistically for age, geographic area, alcohol consumption, and income (Brown et al. 1994).

Smoking mentholated cigarettes may also be a cause of the high and rising esophageal cancer rates among African Americans. In a case-control study of data from the American Health Foundation's ongoing tobacco study, Hebert and Kabat (1989) failed to show a consistent effect of smoking mentholated cigarettes on the risk of esophageal cancer among African Americans. Better designed studies are needed to adequately address this hypothesis.

Oral Cancer

Tobacco use and alcohol use are the predominant risk factors for cancers of the oral cavity and pharynx (commonly referred to as oral cancer) (USDHHS 1989b). African Americans have the highest oral

Figure 4. SEER* cancer incidence and U.S. death rates, 1988–1992, ratio of African American rate to white rate for all ages, by cancer site



*National Cancer Institute's Surveillance, Epidemiology, and End Results Program; rates are age-adjusted to the 1970 U.S. standard population.
†Not otherwise specified.
Source: Kosary et al. 1995.

cancer incidence and death rates in the United States (Tables 2 and 6) (NCI 1996b). Using underlying cause-of-death data compiled by NCHS and U.S. census population enumerations and intercensal population estimates, investigators found that from 1950 to 1990, the death rate for cancers of the oral cavity and pharynx (age-adjusted to the 1970 age distribution of the U.S. population) decreased for white men from 6.6 to 4.2 per 100,000 population. However, for African American men, the death rate increased from 4.8 in 1950 to 11.0 in 1980 and subsequently decreased slightly, to 9.8 in 1990. From 1980 through 1990, the rate for African American men was approximately twice as high as that for white men. The death rate for cancers of the oral cavity and pharynx for African American women exceeded the rate for white women for nearly all of the 41-year period. The death rate increased slightly for white women, from 1.5 to 1.6,

Table 8. Odds ratios (ORs) and 95% confidence intervals (CIs) for the risk of oral cancer associated with cigarette smoking, by race/ethnicity and smoking status, 1984–1985*

	African American		White	
Smoking status	**OR†**	**±CI**	**OR†**	**±CI**
Never smoked	1.0		1.0	
No. of cigarettes per day‡				
1–19	1.2	0.5–2.6	1.2	0.8–1.7
20–39	2.1	1.0–4.4	2.2	1.6–2.9
≥40	2.8	1.0–7.7	2.8	2.0–4.0
Years of cigarette smoking				
1–19	0.9	0.3–2.4	0.6	0.4–1.0
20–39	1.6	0.7–3.3	1.9	1.3–2.5
≥40	2.9	1.2–7.2	3.3	2.3–4.6
Age at smoking initiation (years)				
<17	1.8	0.8–3.9	2.0	1.4–2.7
17–24	1.7	0.8–3.8	1.9	1.4–2.6
≥25	1.2	0.4–3.6	2.2	1.4–3.5
Years since stopped smoking				
0 (never quit)	2.3	1.1–4.7	3.6	2.6–4.8
1–9	1.1	0.4–3.1	1.1	0.7–1.6
10–19	0.1	0.0–1.3	1.1	0.7–1.6
≥20	0.3	0.1–1.7	0.6	0.3–0.9

*Data from four population-based cancer registries in Los Angeles County and Santa Clara and San Mateo Counties near San Francisco-Oakland, metropolitan Atlanta, and the state of New Jersey.

†ORs are adjusted for alcohol consumption, gender, age, study location, and respondent status and are relative to persons who never smoked.

‡Usual number of cigarettes smoked daily when the persons smoked.

Source: Day et al. 1993.

Urinary Bladder Cancer

The incidence of urinary bladder cancer in the United States is highest for whites (Table 6) (NCI 1996b). Among men, mortality is highest for whites; among women, mortality is highest for African Americans (Tables 2 and 6) (NCI 1996b). Differences in bladder cancer risk associated with cigarette smoking for African Americans and whites have been examined in several case-control studies (Table 9), including the ongoing study conducted by the American Health Foundation (Harris et al. 1990), a population-based study conducted in the Detroit metropolitan area (Burns and Swanson 1991), and a population-based study carried out through SEER registries in 1978 (Hartge et al. 1993). In the American Health Foundation study, investigators found that although cigarette smoking was a significant risk factor for bladder cancer among both whites and African Americans, the data suggested a steeper exposure-response relationship among whites (with significant increased risk beginning at exposures of 20 pack-years) than among African American men (with increased risk beginning only after 60 pack-years). However, in a multivariate analysis of the data for men, the risk of bladder cancer did not differ by race. The other two studies showed similar findings for both whites and African Americans in the association between cigarette smoking and bladder cancer. In a smaller case-control study in Orange County, California, no significant interactions were found between smoking and race/ethnicity among whites, Hispanics, Asian Americans, or Pacific Islanders (Anton-Culver et al. 1993). Thus, information currently available suggests that smoking increases the risk of bladder cancer in a similar fashion among both whites and African Americans. In a cohort study of 7,995 Japanese American men who were living in Hawaii, the risk of bladder cancer was 2.9 times higher in current smokers than in nonsmokers (Chyou et al. 1993).

Aromatic amines, such as 4-aminobiphenyl, are considered causative chemical agents in cigarette smoke-induced bladder cancer (Bartsch et al. 1993). As with other potential carcinogens in tobacco smoke, aromatic amines require metabolic activation before interacting with DNA (Miller and Miller 1981). A competing chemical pathway (i.e., acetylation) exists and serves as a detoxification mechanism. Genotyping studies have characterized several variant alleles of the N-acetyltransferase gene, which can result in different rates of chemical acetylation. People who are slow acetylators have increased risk for bladder cancer (Hein 1988). Bell and colleagues (1993) determined

Table 9. Odds ratios for the risk of urinary bladder cancer associated with smoking, by gender, race/ethnicity, and smoking status

Reference, study type, and year	Smoking status	Men		Women	
		African American	White	African American	White
Harris et al. 1990	Never	1.0	1.0	1.0	1.0
Multicenter, hospital-based,	Former	1.6	2.1		1.3
1973–1985	Current	2.0	3.2	3.9*	3.2
Burns and Swanson 1991	Never	1.0	1.0	1.0	1.0
Detroit, population-based	Ever	3.0	2.3	3.8	2.4
	Pack-years				
	< 30	1.9	1.5	3.1	1.7
	30–59.9	4.0	2.6	3.8	2.9
	60–89.9	4.7	2.7	5.0	3.5
	> 90	4.8	3.0	5.2	2.7
Hartge et al. 1993	Never	1.0	1.0	1.0	1.0
SEER† registries,	Former				
population-based, 1978	Cigarettes smoked				
	< 20 per day	1.6	1.3	3.6	2.0
	≥ 20 per day	1.8	1.9	5.0	1.3
	Current				
	Cigarettes smoked				
	< 20 per day	2.2	2.1	1.7	2.0
	≥ 20 per day	4.5	3.0	2.1	3.1

*Ever smokers.
†National Cancer Institute's Surveillance, Epidemiology, and End Results Program.

that 41 percent of African Americans and 55 percent of whites were slow acetylators. A phenotyping study also found the highest percentage of slow acetylators among whites (54 percent), compared with African Americans (34 percent) and Asians (14 percent) (Yu et al. 1994).

In the 1994 study by Yu and colleagues, slow acetylators had higher levels of 3- and 4-aminobiphenyl-hemoglobin adducts, regardless of race and level of smoking (Yu et al. 1994). For African Americans, Asians, and whites, however, the levels of 3- and 4-aminobiphenyl-hemoglobin adducts increased proportionately more for cigarette smokers compared with nonsmokers than for slow acetylators compared to rapid acetylators. In a subsequent study by Yu and colleagues (1995), the slow acetylation phenotype combined with the null genotype of the gene *(GSTM1)* for a phase II detoxification enzyme (glutathione S-transferase) resulted in higher levels of 3- and 4-aminobiphenyl-hemoglobin adducts than did lower risk profiles (i.e., rapid acetylator and/or at least one functional *GSTM1* gene allele). The highest risk profile was seen in 27 percent of whites, 15 percent of African Americans, and 3 percent of Asians.

Several studies show that the highest levels of risk are experienced by smokers, because high levels of exposure to tobacco smoke overwhelm the various phenotypic traits. The differences in risks for various detoxification and activation pathways appear to be most significant among persons who did not smoke or who smoked at very low levels (Yu et al. 1994, 1995; Landi et al. 1996).

Chronic Obstructive Pulmonary Disease

In addition to causing lung cancer, tobacco smoking also causes several non-malignant diseases of the lung and increases the frequency of respiratory symptoms and illnesses (USDHHS 1989b, 1990). Chronic obstructive pulmonary disease (COPD) is a clinical term applied to persons with a permanent airflow obstruction associated with significant impairment (Samet 1989; USDHHS 1989b). Cigarette smokers with COPD have impaired breathing as a result of emphysema (air space enlargement and destruction) and damage to the airways (USDHHS 1984). These smokers also may have chronic bronchitis, which is the term used by epidemiologists and clinicians for chronic sputum production.

Longitudinal studies show that the development of COPD follows sustained excessive loss of ventilatory function of the lung caused by cigarette smoking (USDHHS 1984, 1990). The rate at which ventilatory function declines tends to increase with the amount smoked and to revert to the rate associated with aging after smoking cessation (USDHHS 1990). The frequency of chronic bronchitis is similarly related to smoking pattern.

African Americans

Data from several national surveys have been used to compare the prevalence of COPD among African Americans and whites. McWhorter and colleagues (1989) used data from the 1971–1975 National Health and Nutrition Examination Survey (NHANES I) and the 1982–1984 NHANES I Epidemiologic Follow-up Study (NHEFS) to determine the prevalence of COPD among 14,404 adults aged 25–74 years. African American race/ethnicity was associated with a lower risk for having COPD; 6.2 percent of whites and 3.2 percent of African Americans had COPD.

In the 1990 NHIS, the prevalence of self-reported chronic bronchitis was 55.2 per 1,000 African Americans aged 45–64 years and 42.7 per 1,000 African Americans aged 65 years and older (USDHHS 1991). The prevalence of self-reported emphysema was 3.6 per 1,000 middle-aged African Americans and 41.5 per 1,000 older African Americans. Compared with African Americans, whites in both age groups reported higher prevalences of chronic bronchitis (59.7 for those aged 45–64 years and 73.8 for those aged 65 years and older) and emphysema (13.8 for those aged 45–64 years and 46.1 for those aged 65 years and older). However, self-reports of chronic bronchitis and emphysema, without further validation, are probably subject to substantial misclassification.

African Americans are also less likely than whites to die of COPD (Evans et al. 1987; NCHS 1991). Evans and colleagues (1987) found that in 1982, the age-adjusted COPD death rate was 16.6 per 100,000 whites and 12.8 per 100,000 African Americans. Data for 1986–1988 also show lower death rates from COPD among African Americans than among whites (Desenclos and Hahn 1992). More recent data (Table 2) show that African American men have higher death rates (17.6) for chronic airway obstruction than men in the other three racial/ethnic minority groups, although their rates are lower than rates among white men (20.4). The same pattern is also evident for deaths due to bronchitis and emphysema. The rate of COPD mortality is unexpectedly low among African Americans, given their high prevalence of smoking and related high lung cancer rates. The reasons for this discrepancy remain to be explored. However, whites are more likely than African Americans to have ever smoked and to be former smokers (see Table 37 in Chapter 2). Mannino and colleagues (1997) have observed that death rates from obstructive lung disease relate to rates of ever smoking. These authors suggest that the differences in the race- and gender-specific relative rankings for obstructive lung disease and lung cancer may be because long-term former smokers are more likely to develop obstructive lung disease than lung cancer.

American Indians and Alaska Natives

Little information is available on the occurrence of COPD among American Indians and Alaska Natives. In a 1987 survey of approximately 6,500 American Indians and Alaska Natives aged 19 years and older, 2.4 percent of men and 1.4 percent of women reported having emphysema, compared with 2.7 percent of men and 2.3 percent of women in the general U.S. population (Johnson and Taylor 1991). Rhoades (1990) studied hospitalization and death rates for COPD in American Indians and Alaska Natives. Although the death rates for COPD were lower than from other competing causes, such as chronic liver disease, diabetes, and injuries, the hospitalization rates for COPD exceeded those for cancer and tuberculosis.

Additionally, hospitalization rates and death rates for COPD varied widely between geographic regions. The contribution of COPD to hospitalization rates ranged from 1.6 percent in the Navajo IHS area to 5.1 percent in the Bemidji area; COPD death rates per 100,000 ranged from 1.7 in the Albuquerque area to 10.3 in the Billings area (Rhoades 1990).

Between 1992 and 1994, COPD death rates among American Indian men were approximately two-thirds the rates among whites (Table 2). Data from the Alaska area indicate that from 1979 through 1986, COPD death rates per 100,000 were 31.6 for Alaska Native men, compared with 40.3 for white men in Alaska and 38.3 for men in the United States as a whole (Coultas et al. 1994). The COPD death rates per 100,000 were 22.3 for Alaska Native women, compared with 34.8 for white women in Alaska and 18.6 for women in the United States as a whole. Similarly, death rates for COPD in New Mexico (Samet et al. 1988b) reflect the nationwide pattern of lower rates of death among American Indians compared with whites and are consistent with the lower smoking prevalence among tribes in the southwestern United States (Sugarman et al. 1992). The high rates of COPD among Alaska Natives are probably related to the fact that rates of smoking among Alaska Natives are higher than rates among American Indians elsewhere, particularly in the Southwest.

Asian Americans and Pacific Islanders

Information on COPD morbidity and death among Asian Americans and Pacific Islanders is sparse. National mortality data indicate that the prevalence of deaths from bronchitis and emphysema is lower in this group than among African Americans and whites (Table 2); the death rate from chronic airways obstruction is lowest for Asian Americans and Pacific Islanders. Data from California show that from 1986 through 1987, the overall prevalence of COPD deaths among "Asian and other" persons was lower than among whites but varied widely for specific Asian American and Pacific Islander subgroups (Asian American Health Forum, Inc. 1990).

One of the oldest studies of Asian Americans—the Honolulu Heart Study, conducted in 1965—provides valuable age-related information on smoking and lung function among Japanese Americans. Of the 6,346 Japanese American men aged 46–68 years who underwent spirometric testing, 48 percent were current cigarette smokers, 25 percent were former smokers, and 27 percent had never smoked (Marcus et al. 1988). Airflow obstruction was found in 11.7 percent of the participants. The prevalence of airflow obstruction increased with age and with the amount smoked. For most age and smoking categories, the prevalence of airflow obstruction was lower among Japanese American men than among white men from Connecticut participating in the same study (Beck et al. 1981).

In another recent analysis of data from the Honolulu Heart Program, Japanese American men who continued to smoke showed steeper rates of decline in forced expiratory volume after one second (FEV_1), a measure of pulmonary function, compared with never smokers. Among continuing smokers, FEV_1 decline was significantly associated with duration of smoking. Additionally, the rate of decline in FEV_1 among former smokers became more like that of persons who had never smoked (Burchfiel et al. 1995), consistent with previous reports on the benefits of quitting smoking (USDHHS 1990). In another analysis of data from the same study, Sharp and colleagues (1994) found that a diet composed of large amounts of fish may protect the lungs against damage from cigarette smoking. However, fish consumption was not associated with pulmonary function at higher levels of cigarette smoking (>30 cigarettes/day).

Hispanics

In the 1982–1984 Hispanic Health and Nutrition Examination Survey (HHANES), Puerto Ricans (2.9 percent) had a higher prevalence of reported chronic bronchitis than Mexican Americans (1.7 percent) or Cuban Americans (1.7 percent) (Bang et al. 1990). Chronic airflow obstruction (assessed using spirometry) was present in less than 1 percent of Hispanic adults surveyed in a New Mexico community (Samet et al. 1988a). Similarly, investigators who surveyed Mexican Americans in Tucson, Arizona, found a relatively low prevalence of physician-diagnosed COPD or related diagnoses (Di Pede et al. 1991).

COPD has been reported to occur less frequently among Hispanics than among whites. Surveys in New Mexico have shown, for example, that physician-diagnosed chronic bronchitis or emphysema is less common among Hispanics than among whites (Samet et al. 1982, 1988a). Death rates from chronic obstructive lung diseases and allied conditions are also lower among Hispanics than among whites (Tables 2 and 4). Mortality data for New Mexico indicate that between 1958 and 1982, Hispanic men had a lower death rate from COPD than white men; however, from 1958 through 1982, the death rate from COPD rose

steeply among Hispanic men—from 5.0 per 100,000 in 1958–1962 to 30.1 per 100,000 in 1978–1982 (Samet et al. 1988b). During this same time, COPD death rates increased among Hispanic women but remained comparable to rates among white women (Samet et al. 1988b).

Little information is available on the risk of COPD among Hispanic smokers. In a 1979 respiratory disease survey of Hispanic and white residents of New Mexico's Bernalillo County, Samet and colleagues (1982) found that race/ethnicity was not a significant predictor of current or previous physician-diagnosed chronic bronchitis and emphysema and that no significant interaction existed between race/ethnicity and cigarette smoking. Hispanic ethnicity also was not a significant predictor of the symptoms of chronic cough, chronic phlegm, or persistent wheeze. Similarly, the results of a survey of Hispanics and whites in Tucson indicated that race/ethnicity was not a significant determinant of respiratory symptoms, after survey data were adjusted for cigarette smoking (Di Pede et al. 1991). However, a recent cross-sectional study of urban pregnant women indicated that the prevalence of either doctor-diagnosed asthma or persistent wheeze without asthma was lower among a heterogenous Hispanic population than among white women of similar socioeconomic background (these data were adjusted for cigarette smoking status, family history of asthma, educational level, household exposure to pets, and level of lung function). The authors did not conclude that their data provided evidence of biological protection from wheeze syndromes. An almost fivefold excess risk of persistent wheeze was detected in the total population of urban women who are current smokers (David et al. 1996).

Coronary Heart Disease

In 1994, cardiovascular diseases, comprising a diverse group of disorders including coronary heart disease (CHD), hypertension, stroke, and rheumatic heart disease, caused approximately 940,000 deaths in the United States (NCHS 1996a). The occurrence of specific cardiovascular diseases and their risk factors varies widely among the different racial/ethnic minority groups. Of the cardiovascular diseases, CHD is the single largest cause of death; it results in approximately 480,000 deaths annually in the United States. This section of the report focuses on CHD, which is also termed coronary artery disease or ischemic heart disease (IHD).

Coronary artery disease results from atherosclerosis of coronary arteries. Anatomical lesions become evident in young adults and are usually clinically manifest in the fifth through seventh decades as angina pectoris, myocardial infarction, and sudden cardiac death (Enos et al. 1986; Strong 1986). In this chapter, these clinical manifestations of coronary artery disease are collectively termed CHD.

Numerous non-modifiable and modifiable risk factors contribute to the development of CHD. The non-modifiable factors include aging, gender (men have greater risk), and family history of CHD. The major risk factors that are potentially modifiable include hypertension, cigarette smoking, obesity, hypercholesterolemia, diabetes mellitus, and physical inactivity (Smith and Pratt 1993). The 1983 Surgeon General's report on smoking and health concluded that "Cigarette smoking should be considered the most important of the known modifiable risk factors for coronary heart disease in the United States" (USDHHS 1983, p. iv).

African Americans

The first population-based epidemiological investigations of cardiovascular diseases in the United States that included substantial numbers of African American and white participants began in 1960 in Evans County, Georgia, and Charleston, South Carolina (Saunders 1991). Since 1960, follow-up data for these cohorts and a number of other epidemiological studies have provided information on the combined effects of race/ethnicity and various risk factors for cardiovascular disease. Consistent with findings for the general population, cigarette smoking increased risk of death from CHD among African Americans (Hames et al. 1993; Keil et al. 1995).

Tyroler and colleagues (1984) examined deaths from CHD among the Evans County men, who were followed from 1960 through 1980, and found that the overall rate of death from CHD was lower among African Americans than among whites, with a ratio of 0.86. For current and former smokers, the probability

of dying from all causes and from CHD was higher among whites with a low-socioeconomic status (on the basis of occupation, education, and source of income of the head of household) than among their African American counterparts. However, the analysis did not control for the number of cigarettes smoked, and the data were limited because of the small number of CHD deaths (31) among African Americans.

In the Charleston Heart Study of CHD death rates between 1960 and 1990, Keil and colleagues (1993) found that the age-adjusted, African American-to-white death rate ratios were 0.90 for men and 1.2 for women. After controlling for age and other cardiac risk factors, the researchers found that smoking was associated with a slightly higher risk of dying of CHD among African American men than among white men. White women had a slightly higher risk of dying of CHD than did African American women. These racial/ethnic group differences were not tested for statistical significance, however.

Other investigations that provide information on the risks for CHD and the modification of the effects of smoking, by race/ethnicity, include the Cancer Prevention Study I (CPS-I) (Garfinkel 1984), the NHEFS (Cooper and Ford 1992), the National Mortality Followback Survey (NMFS) (DeStefano and Newman 1993), and the ongoing study of Kaiser Permanente enrollees (Friedman et al. 1997). As part of the CPS-I, death patterns in the original cohort of one million people were described for 1959–1972. The observed-to-expected death rate ratios from CHD among African Americans and whites followed the same pattern as nationwide vital statistics described previously. Overall, the African American-to-white ratios of CHD deaths were 0.78 for men and 1.07 for women. Stratified analyses, by gender, of any effects that the amount of cigarettes smoked might have on CHD deaths showed little difference between African Americans and whites.

Participants in the NHANES I, conducted between 1971 and 1975, were reexamined between 1982 and 1984 as part of the NHEFS (Cooper and Ford 1992). Of the 12,599 participants in the follow-up survey, 10,741 were white and 1,858 were African American. The study showed that cumulative incidence rates of fatal CHD were higher among African Americans (6.2 percent of men and 3.7 percent of women) than among whites (5.6 percent of men and 2.6 percent of women). In contrast, cumulative incidence rates of nonfatal CHD were higher among whites (7.0 percent of men and 4.7 percent of women) than among African Americans (5.0 percent of men and 3.9 percent of women). The risk of new CHD events associated with cigarette smoking was similar among whites and African Americans. These results, however, are limited by the small number of new CHD events among African Americans and the low proportion (approximately 50 percent) of respondents for whom smoking information was collected at baseline.

In a case-control study of CHD deaths among African Americans and whites, DeStefano and Newman (1993) used data from the 1986 NMFS to identify case subjects (n = 803) and 1988 data from the BRFSS to identify control subjects (n = 25,398). When they compared the risk of death among smokers vs. persons who have never smoked (men aged 25–44 years and women aged 25–54 years), the investigators found that among persons without diabetes, African American smokers had a lower relative risk for CHD death than white smokers. However, the 95 percent confidence intervals associated with these odds ratios overlapped each other—an indication that the difference in risk was not statistically significant. In the Kaiser study, the risk of death from CHD has varied among African Americans and whites, but small numbers limit interpretation of these findings (Friedman et al. 1997).

American Indians and Alaska Natives

Most of the available data on CHD among American Indians and Alaska Natives have originated from studies of selected tribes, as reviewed by Young (1994). Investigations of heart disease in southwestern American Indians and Alaska Natives conducted several decades ago showed a low prevalence of CHD relative to the U.S. population and other racial/ethnic groups (Welty and Coulehan 1993). In a descriptive study of CHD deaths occurring from 1948 through 1952 among the Navajos, Smith (1957) found that the standardized death rate ratios for CHD among the Navajos compared with whites were 0.10 for men and 0.12 for women. Since then, numerous other regional investigations of CHD deaths and the incidence of CHD in other tribes of the United States and Canada have been reported. Overall, for studies conducted in the 1950s and 1960s, the ratios of CHD death rates among American Indians and Alaska Natives compared with nationwide rates have ranged from 0.1 to 0.5. An analysis of death statistics from the NCHS showed that crude CHD death rates for individuals classified as American Indians, Eskimos, or Aleuts declined from 100 per 100,000 in 1969–1971 to 67 per 100,000 for the years 1979–1981 (Gillum 1988). A review of New Mexico's vital statistics for 1958–1982 indicates that for American Indian men, CHD death

rates peaked at 101.7 per 100,000 between 1968 and 1972 and fell to 76.6 per 100,000 between 1978 and 1982 (Becker et al. 1988). For American Indian women, the CHD death rate peaked at 63.0 per 100,000 between 1963 and 1967 and declined to a low of 28.3 per 100,000 between 1978 and 1982.

In a recent analysis of mortality data for 1992–1994 (Table 2), the rate of death due to CHD was lower among American Indian and Alaska Native men (100.4) and women (45.9) than among white men (132.5) and women (62.9). The ratio of CHD death rates among American Indians and Alaska Natives compared with whites was .76 for men and .73 for women. The fact that these ratios are higher than ratios from earlier studies suggests that CHD deaths among American Indians and Alaska Natives may be increasing (Welty and Coulehan 1993; Young 1994).

Risk factors for cardiovascular disease were investigated recently in a large multi-tribal study of American Indians. The results showed that mean levels of total, low density lipoprotein, and high density lipoprotein cholesterol were lower in American Indians than in the U.S. general population. Prevalence of hypertension, non-insulin dependent diabetes mellitus, and obesity were very high, but varied considerably among tribes and geographic regions (Welty et al. 1995). A second study found that levels of serum cholesterol were lower in American Indian smokers who attended a stop smoking clinic than in African American and white smokers from population-based samples (Folsom et al. 1993). However, fibrinogen levels and the prevalence of abdominal obesity were higher in American Indian smokers than in African Americans and whites.

The IHS is another source of nationwide and regional health statistics on CHD deaths. Because the mortality data in IHS reports combine all cardiovascular diseases under "diseases of the heart" (IHS 1994b), this information cannot be compared directly with CHD data from other sources. Between 1989 and 1991, diseases of the heart accounted for 21.9 percent of deaths in all IHS areas, with a crude death rate of 115.1 per 100,000 (IHS 1994b). These data indicate cardiovascular diseases were the leading cause of death among American Indians. However, because Indian race/ethnicity was underreported on death certificates in several IHS areas, including California and Oklahoma as well as Portland, Oregon, this death rate may be incorrect.

Death rates from heart diseases vary widely among people in the 12 IHS areas. From 1989 through 1991, the rate of death from heart diseases per 100,000 was lowest in the Albuquerque area (88.0) and highest in the Aberdeen area (249.0) (IHS 1994a). These wide variations in deaths from diseases of the heart parallel the wide variations in the prevalence of cigarette smoking among the various tribes (Sugarman et al. 1992; Coultas et al. 1994) (see also Chapter 2). For example, in a 1985–1988 survey of adult American Indians in the southwestern United States, 18.1 percent of men and 14.7 percent of women reported current smoking, compared with 48.4 percent of men and 57.3 percent of women in the Plains states (Sugarman et al. 1992).

Data to assess the influence of tobacco use on the risk of cardiovascular disease among American Indians are extremely limited. One study has shown that cigarette smoking increases the risk for CHD among American Indians, after adjustment for other risk factors (Howard et al. 1995). In fact, most studies presented in this section describe cardiovascular disease morbidity and mortality without ever assessing the influence of tobacco use. Nevertheless, cardiovascular disease is the leading cause of death among American Indians and Alaska Natives (NCHS 1996b), and tobacco use is an important risk factor for this disease. More studies are needed to evaluate the independent effect of tobacco use on the risk of cardiovascular disease among American Indians and Alaska Natives.

Asian Americans and Pacific Islanders

Limited data are available on risk factors and CHD among Asian Americans and Pacific Islanders in the United States (Yu 1991). A recent study of nationwide mortality indicated that Asian Americans and Pacific Islanders have lower rates of death from CHD than whites (Table 2).

In an analysis of 1980 death rates in Los Angeles County, Frerichs and colleagues (1984) found that the age- and gender-adjusted death rates for cardiovascular diseases varied widely among Asian Americans and Pacific Islanders. Koreans had the lowest rate per 100,000 (82), and Japanese had the highest rate (162). These rates were substantially lower than the overall rate for the county population, with rate ratios of 0.26 for Koreans and 0.52 for Japanese. Specific data on CHD deaths and cigarette smoking prevalence were not available.

In another study, Reed and colleagues (1983) used death records from Hawaii to describe age-adjusted, gender-specific, and racial- and ethnic-specific rates of CHD deaths occurring from 1940 through 1978. For all racial/ethnic minority groups, CHD death rates were higher among men than among women. Death

rates and the temporal trends in deaths varied widely between the different groups, with the highest death rates among Native Hawaiians and the lowest among Japanese. Filipino men had the greatest increase in CHD death rates, surpassing the rates for whites in 1978. Although most of the other groups had declines in CHD death rates between 1960 and 1970, CHD death rates for Native Hawaiian men remained level.

In 1965, three cohorts of Japanese men were assembled in Japan, Honolulu, and San Francisco to investigate the differences in CHD deaths observed among Japanese men living in the three locales (Worth et al. 1975; Yano et al. 1988). From 1965 through 1972, Worth and colleagues (1975) found that age-specific death rates were highest among the San Francisco men, intermediate among those living in Honolulu, and lowest among those living in Japan. For example, among men 60–64 years of age, the annual CHD death rates per 1,000 were 4.9 in San Francisco, 3.9 in Honolulu, and 2.1 in Japan. Mortality data for 1965–1980 indicate that the age-adjusted CHD death rate ratio for men in Honolulu compared with men in Japan was 1.4 (Yano et al. 1988). The age-adjusted mean levels of most CHD risk factors, including cigarette smoking (measured in cigarette-years), were also higher among Honolulu men. After adjusting for these risk factors, the rate ratio for CHD declined to 1.17, indicating that more than half of the elevated CHD death rate was due to the higher mean levels of CHD risk factors among Honolulu men.

In the Honolulu Heart Program cohort, composed of 7,705 Japanese men 45–68 years of age living in Hawaii who had no evidence of CHD at enrollment between 1965 and 1968, numerous analyses were conducted to further examine predictors of CHD incidence and death (Reed et al. 1982, 1987; Yano et al. 1984; Benfante et al. 1991). A higher level of acculturation was found to be associated with CHD risk factors and incidence during the 1971–1979 follow-up (Reed et al. 1982). Men who were primarily Japanese in culture smoked an average of seven cigarettes per day, whereas men who were more acculturated smoked an average of 11 cigarettes per day. A similar pattern was seen for total CHD incidence, which was highest among the men who were more acculturated (62 per 1,000) and lowest among the men who were primarily Japanese in culture (35 per 1,000).

Yano and coworkers (1984) conducted detailed analyses of the relationship between risk factors and the incidence of CHD during a 10-year period, beginning after the enrollment period (1965–1968). Systolic blood pressure, number of cigarettes smoked, and cholesterol level were all independently associated with the occurrence of all CHD events. Alcohol consumption was found to be a protective factor. Subsequent analyses of 20-year follow-up data from the same study showed that cigarette smoking was independently associated, in a dose-response manner, with increased risk of CHD (fatal or nonfatal) and aortic aneurysm (Goldberg et al. 1995). The risk for angina was elevated in persons who smoked more than 20 cigarettes per day. Another analysis suggested that high levels of fish intake might limit the increased risk among heavy smokers, although these findings should be considered preliminary (Rodriguez et al. 1996). In addition, cigarette smoking was found to be independently associated with increased prevalence of myocardial lesions in Japanese men with minimal evidence of coronary atherosclerosis at autopsy (Burchfiel et al. 1996).

Hispanics

Because of incomplete data, the NCHS reported data from 1985 death certificates on decedents of Hispanic origin for only 17 states and the District of Columbia (NCHS 1996b). By 1990, data for 47 states and the District of Columbia were reported. The NCHS estimated that the 1990 reporting area encompassed 99.6 percent of the U.S. Hispanic population (NCHS 1996b). In 1993 and 1994, only Oklahoma did not provide information on Hispanic origin (NCHS 1996a,b).

Between 1992 and 1994, the overall rate of death from CHD in the United States was lower among Hispanics than among whites (Table 2). Among the various Hispanic subgroups, Puerto Rican men had the highest death rates per 100,000 (118.6); similarly, CHD death rates among Puerto Rican women (67.3) were higher than among Mexican (44.2) and Hispanic (42.4) women.

Nationwide death rates among Hispanics and whites have been estimated by using data collected by the U.S. Bureau of the Census as part of the Current Population Survey (CPS) (Sorlie et al. 1993). Baseline interview data were obtained between 1973 and 1985 from approximately 40,000 Hispanics and 660,000 non-Hispanics aged 25 years and older. Death rates for these two groups were ascertained up to nine years after the initial interview through the National Death Index. Age-adjusted death rate ratios for CHD were lower among Hispanics than among non-Hispanics (0.60 for men and 0.75 for women). Further details for the different Hispanic subgroups were not provided.

In addition to nationwide data on the occurrence of CHD among Hispanics, regional studies have been conducted in California (Schoen and Nelson 1981;

Frerichs et al. 1984), Colorado (Rewers et al. 1993), New Mexico (Buechley et al. 1979; Becker et al. 1988), and Texas (Stern and Gaskill 1978; Stern et al. 1987; Mitchell et al. 1991; Goff et al. 1993). In general, these investigations have consistently shown that Hispanic men have lower CHD death rates than white men, although the Colorado study found little evidence for lower CHD death rates among Hispanics without diabetes (Rewers et al. 1993).

The prevalence of angina was also found to be lower among Hispanics than among whites in a review of data from a sample of Mexican Americans participating in the 1982–1984 HHANES and of whites surveyed in the 1976–1980 NHANES II (LaCroix et al. 1989). Prevalence rates based on self-reports were 2.8 percent among Mexican American men and 3.9 percent among white men, and they were 5.4 percent among Mexican American women and 6.3 percent among white women. As with African Americans, no significant differences were observed in the distribution of cardiovascular disease risk factors among Mexican Americans with and without self-reported angina. The results of this survey were limited by the lack of smoking-specific analyses for Mexican Americans.

Several investigators also have examined the cardiovascular disease risk factor profiles of Hispanics (Mitchell et al. 1991; Shea et al. 1991; Winkleby et al. 1993). Shea and colleagues (1991) analyzed 1989 BRFSS data on 636 Hispanics, most of whom were Puerto Ricans, Dominicans, and Cubans living in New York City. Although the overall risk factor profile was high among these Hispanic subgroups, the prevalence of current cigarette smoking varied by level of education. Mitchell and colleagues (1991) obtained information on cardiovascular disease risk factors from 5,148 subjects, including 3,281 Mexican Americans, who participated in the San Antonio Heart Study from 1979 through 1988. The overall risk profiles were higher among Mexican Americans. For men of all ages, the prevalence of current smoking was higher among Mexican American men (36.7 percent) than among white men (30.4 percent). For women of all ages, however, the prevalence of current smoking was lower among Mexican American women (21.0 percent) than among white women (26.8 percent). For both men and women, the number of cigarettes smoked per day was consistently lower among Mexican Americans than among whites. More recently, Winkleby and colleagues (1993) examined the cardiovascular disease risk profiles of 756 Hispanics and 756 whites participating in California surveys from 1979 through 1990. Hispanics and whites were matched by age, gender, educational level, city of residence, and time of survey. Whites had a higher prevalence of smoking (34.2 percent) than Hispanics (24.0 percent), and they smoked more cigarettes per day (19.7) than Hispanics (11.4).

Few investigators have compared the risk of smoking-related CHD between Hispanics and members of other racial/ethnic groups. Mitchell and coworkers (1991) determined the 1979–1988 prevalence of myocardial infarction among 3,281 Mexican Americans and 1,867 whites who participated in the San Antonio Heart Study. On the basis of either electrocardiograms or self-reports, the risk of myocardial infarction among Mexican Americans compared with whites was 24 percent lower for men but 40 percent higher for women. Race/ethnicity did not appear to modify the risk for myocardial infarction.

Cerebrovascular Disease

Cerebrovascular disease is a major cause of mortality and morbidity in the United States every year. In 1994, a total of 153,306 deaths in the United States were caused by cerebrovascular disease (NCHS 1996a).

Stroke, the major form of cerebrovascular disease, results from an interruption of the arterial blood supply to the central nervous system, primarily the brain. Most commonly, the interruption of the arterial blood supply results from an occlusion of an artery in the brain by a thrombus, which may have resulted from atherosclerosis or blood clots from a diseased heart. A less common mechanism for development of stroke is rupture of a blood vessel in the brain. Other diagnoses under the general rubric of cerebrovascular disease include transient cerebral ischemia and cerebral arteriosclerosis.

As for CHD, risk factors for stroke may be divided into non-modifiable and modifiable characteristics. The non-modifiable factors include aging, gender, and family history of stroke. The major risk factors that are potentially modifiable include hypertension, hypercholesterolemia, diabetes mellitus, cigarette smoking, and heart disease (USDHHS 1989b).

African Americans

The rate of death from cerebrovascular disease in the United States is higher among African Americans than other racial/ethnic groups and whites (Table 2). For 1992–1994, the rate of death (per 100,000 population) from cerebrovascular disease was twice as high among African American men (53.1) as among white men (26.3) and almost twice as high among African American women (40.6) as among white women (22.6).

Similar patterns have been observed in studies of persons belonging to health plans. Klatsky and colleagues (1991) determined the incidence of hospitalization for cerebrovascular disease among 74,096 whites and 33,041 African Americans who were members of a prepaid health plan in northern California from 1978 through 1984. The relative risks for hospitalization for hemorrhagic cerebrovascular disease, cerebral thrombosis, and nonspecific cerebrovascular disease were higher among African Americans than among whites. Because hypertension is the strongest risk factor for stroke, the high prevalence of hypertension among African Americans partially explains this pattern (Braithwaite and Taylor 1992). Despite limited data on the link between smoking and stroke among African Americans, the high rate of cigarette smoking among African Americans (see Chapter 2) clearly appears to have played a significant role in elevating the risks of stroke in this population (USDHHS 1983).

American Indians and Alaska Natives

In recent years, age-adjusted death rates for cerebrovascular disease were slightly lower among American Indian and Alaska Native men and women than among white men and women (Table 2). For example, from 1992–1994, the age-adjusted death rate per 100,000 population for cerebrovascular disease was 23.9 for American Indian and Alaska Native men, 26.3 for white men, 21.1 for American Indian and Alaska Native women, and 22.6 for white women.

Young's (1994) recent review of the literature indicates that few investigations have focused on cerebrovascular disease among American Indians or Alaska Natives. Middaugh (1990) found little difference between the death rate from cerebrovascular disease among Alaska Natives and persons of other race/ethnicities, with death rate ratios of 1.13 for men and 1.03 for women. In a review of 1958–1987 vital statistics data from New Mexico, Kattapong and Becker (1993) observed lower rates of death from cerebrovascular disease among American Indians than among Hispanics and whites. For American Indian men, cerebrovascular disease death rates per 100,000 peaked at 70.1 between 1968 and 1972 and fell to 31.3 between 1983 and 1987. Cerebrovascular disease death rates for American Indian women also peaked at 55.7 between 1968 and 1972 and declined to a low of 19.3 between 1983 and 1987.

Asian Americans and Pacific Islanders

From 1992 through 1994, the age-adjusted death rate per 100,000 population for cerebrovascular disease was 29.3 for Asian American and Pacific Islander men, 26.3 for white men, 22.4 for Asian American and Pacific Islander women, and 22.6 for white women (Table 2).

In a study of stroke deaths occurring between 1965 and 1972 among Japanese men living in Japan, Honolulu, and San Francisco, age-specific stroke death rates were highest among men living in Japan (Worth et al. 1975). Among men 60–64 years of age, annual death rates per 1,000 men were 5.4 in Japan, compared with 2.5 in San Francisco and 1.1 in Honolulu. For CHD, however, the death rates in Japan were lower than rates in Honolulu and San Francisco. Data from the Honolulu Heart Program suggest that other risk or protective factors associated with a Japanese diet, such as high alcohol intake and low intake of food from animal sources, may play important roles in the development of stroke and CHD in Honolulu and Japan, along with smoking, older age, high systolic blood pressure, and high serum cholesterol and glucose levels (Reed 1990).

In a study of 1980 death rates among Asian Americans in Los Angeles, Frerichs and colleagues (1984) found that Koreans had the lowest age- and gender-adjusted death rate for cerebrovascular disease (48 per 100,000) and that Japanese had the highest rate (80 per 100,000). When the investigators compared the average age- and gender-adjusted death rates for these Asian Americans with rates for the entire county, the mortality ratio was 1.07 for Japanese and 0.65 for Koreans.

Cigarette smoking was found to be an independent risk factor for stroke among men of Japanese ancestry who participated in the Honolulu Heart Program (Abbott et al. 1986). For all types of stroke, the estimated relative risk of smoking, adjusted for age and other major risk factors, was 2.5. This risk decreased to 1.5 among men who quit smoking during the six-year follow-up period and increased to 3.5 among men who continued to smoke, indicating that cigarette smoking is a cause of stroke in Japanese men.

A subsequent analysis of participants in the Honolulu Heart Program indicated that cigarette smoking significantly increased the risk for thromboembolic stroke (Goldberg et al. 1995).

Hispanics

Studies about stroke among Hispanics have focused on the magnitude of this outcome in relation to other racial/ethnic groups. Between 1986 and 1988, the overall rate of death from cerebrovascular disease was lower among Hispanics than among whites in the United States (Desenclos and Hahn 1992). When cerebrovascular disease death rates for Hispanics and whites were compared, the mortality ratio for Hispanic men was 0.89, and the ratio for Hispanic women was 0.84. Of the different Hispanic subgroups, Mexican Americans had the highest death rates from cerebrovascular disease. Sorlie and colleagues (1993) had similar observations when they estimated death rates using census data collected between 1973 and 1985. Age-adjusted death rate ratios for cerebrovascular disease were lower among Hispanics than among whites (0.60 for men and 0.76 for women). No details were provided for the different Hispanic subgroups. In more recent years, age-adjusted death rates for cerebrovascular disease were slightly lower among Hispanic men and women than among white men and women. For example, from 1992–1994, the age-adjusted death rate per 100,000 population for cerebrovascular disease was 22.7 for Hispanic men, 26.3 for white men, 16.7 for Hispanic women, and 22.6 for white women (Table 2).

Regional studies in California (Frerichs et al. 1984), New Mexico (Kattapong and Becker 1993), and Texas (Stern and Gaskill 1978) provide further evidence that Hispanics have a lower risk of death from cerebrovascular disease than do whites and African Americans. Frerichs and colleagues (1984) compared 1980 death rates among the different racial/ethnic groups in Los Angeles County. The age- and gender-adjusted cerebrovascular disease death rates per 100,000 were 64 for Hispanics compared with 76 for whites (death rate ratio, 0.84) and 94 for African Americans (death rate ratio, 0.68).

After reviewing New Mexico vital statistics data for 1958–1987, Kattapong and Becker (1993) described time trends in deaths from cerebrovascular disease among Hispanics, whites, and American Indians. Except for the period 1983–1987, Hispanic men had lower death rates than white men. From 1983 to 1987, the ratio of death rates among Hispanic men (45.8 per 100,000) compared with the rate among white men (36.1 per 100,000) was 1.27. For women, the pattern of death rates was less consistent. From 1958 through 1972, Hispanic women had higher death rates than white women; between 1973 and 1982, they had lower rates; and from 1983 through 1987, Hispanic women had slightly higher death rates (43.1 per 100,000) than white women (39.3 per 100,000).

Stern and Gaskill (1978) examined temporal trends in stroke deaths from 1970 through 1976 among Hispanics and whites living in Bexar County, Texas, which includes San Antonio. Stroke deaths were generally lower among Hispanic women, but no significant difference was observed between the rates among men of either racial/ethnic group. Furthermore, no temporal trends in stroke deaths were evident for either gender or racial/ethnic group.

Cigarette smoking probably explains some of the risk of stroke among Hispanics. However, data to assess the strength of this relationship are not available. Because the data presented here suggest that stroke is a leading cause of morbidity and death among Hispanics (NCHS 1993), future studies should examine the specific role that cigarette smoking plays.

Smoking and Pregnancy

Smoking has long been known to be associated with poor outcomes for the infants of mothers who smoke. Mean infant birth weight and low birth weight (LBW) (<2,500 grams or <5.5 pounds) are often studied as measures of fetal morbidity because birth weight is easy to measure. LBW can result either from preterm delivery (<37 weeks' gestation) or from intrauterine growth retardation, but the distinction may be difficult to make. Smoking has been associated with an average decrease in birth weight of about 200 grams as well as LBW, preterm birth, perinatal mortality, and infant mortality (USDHHS 1980, 1989b; Malloy et al. 1988; English and Eskenazi 1992).

Evidence that the relationship between smoking and poor infant outcomes is causal has been strengthened by recent studies that used biomarkers of tobacco exposure, such as saliva and serum cotinine (Bardy et al. 1993; Li et al. 1993; English et al. 1994). Bardy and colleagues (1993) demonstrated a dose-response relationship between serum cotinine and decreased gestational age, decreased birth weight, and decreased crown-heel length.

The exact mechanisms whereby smoke exposure affects the fetus are poorly understood. Carbon monoxide, which impairs oxygen delivery to the fetus, and nicotine, which impairs placental blood flow, have been implicated as the causative substances in tobacco smoke (USDHHS 1980).

The infant outcomes most often studied have been LBW and infant mortality. Sudden infant death syndrome (SIDS) is an important component of infant mortality because it is the most common cause of death among infants older than one month of age. Available data show that LBW, infant mortality, and SIDS occur differentially in different racial/ethnic groups in the United States (Table 10) (Kleinman 1990; NCHS 1994). In general, whites have lower rates of these conditions and other racial/ethnic groups tend to have higher rates, but considerable variation exists.

Several studies have reported different effects of smoking on LBW, infant mortality, and SIDS across racial/ethnic minority groups. This section focuses only on those studies that have investigated potential racial/ethnic group differences in the relationship between smoking and infant outcomes.

Studies of Low Birth Weight

Nearly 25 years ago, the possibility was raised that smoking might have a differential effect on reproductive outcomes in different racial/ethnic groups (Lubs 1973). In a study of all singleton live births at Yale-New Haven Hospital in 1972, Lubs reported a difference in the effect of maternal smoking on LBW among 783 African American and 3,415 white women. A strong dose-response relationship was observed between the number of cigarettes smoked during pregnancy and infant LBW (defined as ≤2,500 grams for whites and ≤2,350 grams for African Americans). Among African American women, smoking 20 or more cigarettes per day was associated with a threefold increase in LBW, compared with only a twofold increase among white women. These racial/ethnic group differences were not explained by differences in age, prepregnancy weight, education, or marital status.

Several more recent studies also provide evidence for the possibility of a differential effect of smoking on LBW among white and African American women. English and colleagues (1994) used interview data from the Child Health and Development Studies, conducted from 1959 through 1966 in California. Stored serum samples were analyzed for cotinine, and the levels were compared with self-reported cigarette consumption and infant birth weight for 374 African American and 829 white pregnant smokers separately. African American pregnant smokers were found to have higher serum cotinine levels than white pregnant smokers after the data were controlled for smoking dose and demographic confounders. No racial/ethnic minority group difference was found in the rate of decrease in mean birth weight per given amount of cotinine in the serum of women who smoked. These data suggest that cigarette smoking may have a greater effect on birth weight among African Americans than among whites because higher cotinine levels are present in African American women than in white women who smoke the same amount; the higher cotinine levels may result from a greater intake of tobacco smoke per cigarette by African American women than by white women.

Li and colleagues (1993) found a differential effect of smoking reduction during pregnancy on infant birth weights among African American and white women. Study subjects were 803 participants in an experimental trial of smoking cessation for pregnant women in Alabama; self-reported smoking was validated with saliva cotinine. Reduction was defined as a minimum drop in saliva cotinine values between the baseline (early pregnancy) visit and the late pregnancy visit. Smoking reduction increased the birth weight of infants of both African American and white women, but racial/ethnic group differences were present. Among white women, a reduction in smoking increased infant birth weight regardless of the baseline cotinine value. However, among African American women with high baseline cotinine values, a reduction in smoking had no effect on infant birth weights. The authors suggested that high levels of cigarette smoking (as detected by high cotinine levels) early in pregnancy may have irreversible effects on African American infants.

Another recent study reported a differential effect of smoking on LBW (<2,500 grams) among multiparous African American and white women, but in the opposite direction (Neggers et al. 1994). Among African American women, the investigators found no significant difference in birth weight between smokers

Table 10. Rates of selected infant outcomes, by mother's race/ethnicity,* United States

Reference	Outcome/years	African American	American Indian and Alaska Native	Asian American and Pacific Islander				
				Total	Chinese	Japanese	Filipino	Other
NCHS, public use data tapes, 1992[§]	Low-birth-weight (<2,500 grams) rate per 100 live births, 1992	13.4	6.2	6.6	5.2	7.5	7.4	6.9
NCHS 1994[§]	Infant mortality rate per 1,000 live births, 1987	17.8	13.0	7.3	6.2	6.6	6.6	7.9
Kleinman 1990	Sudden infant death syndrome rate per 1,000 live births, 1983–1984	2.41	3.44	0.95	NA	NA	NA	NA

*The categories African American and white include persons of Hispanic and non-Hispanic origin. Conversely, persons of Hispanic origin may be included in other categories as well.
†Reported for selected states only; reporting areas for Hispanic origin vary by year.

and nonsmokers, whereas among white women, the infants of smokers weighed significantly less than those of nonsmokers. However, no information was available on the number or type of cigarettes smoked or the biomarker of exposure; these results were adjusted only for the mother's parity, age, height, and alcohol consumption as well as the infant's gender and gestational age at birth. In addition, the study was not designed to study the relationship between smoking and LBW but to determine whether the relationship between maternal triceps skinfold thickness and infant birth weight was modified by smoking and race/ethnicity.

Two studies have reported that smoking is related to an elevated risk of LBW among both African American and white women, but neither study found significant racial/ethnic group differences. In a population-based, case-control study of African American and white women delivering singleton infants without congenital anomalies in a large urban county of California, the Alameda County Low Birth Weight Study Group (1990) found that the risk of LBW associated with regular smoking throughout pregnancy was 3.0 (95 percent confidence interval [CI], 1.7–5.3) for white women and 3.6 (95 percent CI, 2.4–5.6) for African American women (adjusted for age, parity, prepregnancy weight, socioeconomic status, alcohol use, prior LBW birth, and prenatal care). Unfortunately, the authors were unable to adjust the data for the number of cigarettes smoked.

Castro and colleagues (1993) reported a study of maternal smoking and substance abuse during pregnancy and found similar associations between smoking during pregnancy and small size for gestational age (birth weight of less than the 10th percentile for gestational age) for African American and white women (odds ratio [OR] for African American women, 2.0 [95 percent CI, 1.3–3.1]; OR for white women, 2.4 [95 percent CI, 1.7–3.0]). These results were adjusted for maternal age, parity, marital status, insurance status, alcohol use, marijuana use, and other drug use; however, no information was available on the number of cigarettes smoked or the biomarker of exposure.

Few studies have examined the relationship between smoking and LBW among Hispanic populations. Cohen and colleagues (1993) analyzed birth weight data on 19,571 Hispanic infants and 206,973 white infants (those whose mothers did not indicate they were of Hispanic origin) born in Massachusetts

	Hispanic†					
Total	Mexican American	Puerto Rican	Cuban	Central and South American	Other‡	White
6.4	6.0	8.8	6.0	5.6	7.5	5.9
8.2	8.0	9.9	7.1	7.8	8.7	8.2
NA	0.84	1.38	0.83	0.53	1.52	1.21

‡Includes persons of unknown Hispanic origin.
§Data calculated to one significant digit.
NA = data not available.

between 1987 and 1989 and found that the incidence of LBW ranged from a high of 73 per 1,000 Puerto Rican infants to a low of 32.2 per 1,000 Cuban infants. The crude percentage of LBW was higher for smokers than for nonsmokers in each racial/ethnic group; however, multivariate adjusted risks were not presented for racial/ethnic groups separately.

Several studies have demonstrated associations between smoking and LBW in specific racial/ethnic minority groups, including Puerto Ricans (Becerra and Smith 1988), Mexican Americans (Wolff et al. 1993), North American Indians (Godel et al. 1992), and African Americans (Jacobson et al. 1994; Johnson et al. 1994). In each instance, smoking was shown to be related to lower birth weight; however, these studies did not provide data on other racial/ethnic groups, which might have allowed comparisons.

The percentage of LBW (<2,500 grams) in the United States in 1993 was higher overall for smokers (11.8 percent) than for nonsmokers (6.6 percent) (NCHS 1996b). Although a higher percentage of white mothers (16.8) smoked during pregnancy than did African American mothers (12.7), African American women had a higher percentage (13.3) of LBW live births than white women (6.0) did in 1993. Age- and racial/ethnic-specific analyses of population data may be more revealing. Land and Stockbauer (1993), for example, found that the teenage-specific LBW rate for African Americans in Missouri dropped by 13.6 percent from 1978–1990, concomitant with a drop in cigarette smoking prevalence among young African American mothers. Analyses of individual data statistically controlled for confounding factors such as preterm deliveries and maternal parity, weight, and access to health care (USDHHS 1989a) would be preferable. The studies of individuals that are reported in this section provide more useful data than do population-based ecological comparisons on the relationship between cigarette smoking and the increased occurrence of LBW in various racial/ethnic groups.

Studies of Infant Mortality and Sudden Infant Death Syndrome

Only one study has examined the risks of smoking associated with overall fetal and infant mortality in specific racial/ethnic groups (Kleinman et al. 1988). The authors used data from Missouri live birth, fetal death, and infant death certificates for births during

Table 11. Risk of sudden infant death syndrome associated with smoking, by race/ethnicity, selected studies, United States

Reference	Exposure/years	African American		American Indian and Alaska Native		Asian American and Pacific Islander	
		OR*	CI†	OR	CI	OR	CI
Li and Daling 1991‡	Active smoking 1984–1989	3.1	1.7–5.9	1.4	0.9–2.4	2.7	1.1–6.6
Schoendorf and Kiely 1992§	Passive exposure 1988	1.8	1.0–3.0	NA	NA	NA	NA
	Combined exposure 1988	3.1	2.3–4.2	NA	NA	NA	NA
Klonoff-Cohen et al.Δ 1995	Passive exposure 1989–1992	5.0	1.1–22.8	NA	NA	NA	NA

*OR = odds ratio.
†CI = 95% confidence interval.
‡Li and Daling assessed the risk, by mother's ethnicity, associated with active maternal smoking during pregnancy; ORs are adjusted for maternal age, marital status, prenatal care, parity, and birth weight.
§Schoendorf and Kiely assessed the risk, by mother's ethnicity, associated with (1) passive smoking (maternal smoking after birth but not during pregnancy) and (2) combined exposure (maternal smoking during pregnancy and after birth); ORs are adjusted for maternal age, education, and marital status.
ΔKlonoff-Cohen et al. assessed the risk, by infant's ethnicity, associated with total passive smoke exposure from all adults (mother, father, live-in adults, and day-care providers); ORs are adjusted for birth weight, routine sleep position, medical conditions at birth, breast-feeding, prenatal care, and maternal smoking during pregnancy.
NA = data not available.

1979–1983 to examine the risk of mortality associated with smoking during pregnancy. They found no significant variation in the effects of smoking on African American and white women, with adjusted ORs ranging from 1.3 to 1.6, depending on parity and the amount smoked.

Three studies have examined the effects of smoking on SIDS in specific racial/ethnic minority groups (Table 11) (Li and Daling 1991; Schoendorf and Kiely 1992; Klonoff-Cohen et al. 1995). Li and Daling (1991) used data from Washington State birth records from 1984 through 1989, linked with infant death records. After adjusting the data for maternal age, marital status, prenatal care, parity, and birth weight, they found a statistically significant increased risk of SIDS associated with maternal smoking during pregnancy in all racial/ethnic groups except American Indians (Table 11). The ORs were not significantly different between groups, except between African Americans and American Indians. No information was available on the number of cigarettes smoked or the biomarker of exposure.

Schoendorf and Kiely (1992) used data from the 1988 National Maternal and Infant Health Survey to study the association between SIDS and maternal smoking (either passive [only after birth] or combined [during pregnancy and after birth]) among infants of normal birth weight. They found similar increased risks of SIDS among African American and white infants exposed to maternal smoking (Table 11), after adjusting the data for maternal age, education, and marital status. Although white mothers reported heavier smoking than African American mothers, the authors did not adjust their findings for the number of cigarettes smoked.

Hispanic		White	
OR	CI	OR	CI
5.5	1.4–22.0	2.2	1.8–2.6
NA	NA	3.1	2.3–4.2
NA	NA	1.8	1.0–3.0
2.6	0.9–7.3	3.4	1.6–7.2

Klonoff-Cohen and colleagues (1995) conducted a 1989–1992 case-control study of passive smoking and SIDS in five counties in southern California. The OR for SIDS associated with all types of passive smoke exposure combined was 3.50 (95 percent CI, 1.81–6.75), after adjustment for birth weight, routine sleep position, medical conditions at birth, breast-feeding, prenatal care, and maternal smoking during pregnancy. The evidence suggested a dose-response relationship, with an increased risk of SIDS associated with increased passive exposure to smoke. The authors also stratified the data by racial/ethnic group and found similar effects across groups (Table 11), although the results were not adjusted for the number of cigarettes smoked.

Health Problems Affecting Pregnant Women

Smoking is related to a variety of health problems affecting pregnant women, ranging from ectopic pregnancy to abruptio placentae (USDHHS 1980; Rosenberg 1987), but race- and ethnic-specific data are not generally available. In addition to exploring smoking's effects on fetuses and infants, future research should focus on the race- and ethnic-specific effects of smoking on the pregnant woman herself.

Implications

The question of whether race- and ethnic-specific differences exist in the relationship between smoking and infant outcomes has not been satisfactorily resolved. Many intriguing questions have been raised, but investigators have not yet determined the exact nature of such differences or what factors mediate them.

Comparative studies have been hampered by inconsistent and inadequate measurement of exposure. For example, few investigators have fully explored issues of dose of smoking such as the number of cigarettes smoked or the levels of biomarkers, although the amount of smoking during pregnancy does differ among racial/ethnic minority groups (see Chapter 2). Moreover, even though the timing of smoking during pregnancy may play a critical role in the development of LBW (Lieberman et al. 1994), few studies of LBW have separately assessed the effects of smoking during each trimester of pregnancy. Patterns of quitting and reducing smoking during pregnancy may in fact differ by race/ethnicity.

Racial/ethnic group differences in nicotine metabolism may also be important (Wagenknecht et al. 1990; English et al. 1994). African American pregnant smokers appear to have higher serum cotinine levels than white pregnant smokers when the data are controlled for nicotine dose (English et al. 1994). Thus, fetal exposure may be higher among African Americans than among whites for a given number of cigarettes smoked.

Racial/ethnic group differences in oxygen-carrying capacity may also play a role in mediating the effects of smoking. In 1973, Lubs suggested that the increased effects of smoking on birth weight among African American women might in part be explained by higher rates of sickle cell trait or glucose-6-phosphate dehydrogenase (G6PD) deficiency, which impair oxygen-carrying capacity (Lubs 1973). No published reports have examined Lubs's hypothesis. In addition, anemia, which is more prevalent among African American women, may be a risk factor for preterm delivery (Hogue and Yip 1989).

Future studies of smoking and pregnancy outcomes should consider racial/ethnic group differences in the timing of smoking during pregnancy, nicotine metabolism, and factors that affect oxygen-carrying capacity, such as sickle cell trait, G6PD deficiency, and anemia.

Summary of Health Consequences from Active Cigarette Smoking

Attempts to predict racial- and ethnic-specific rates of disease incidence and mortality from racial- and ethnic-specific cigarette smoking prevalences are of limited value, because other factors can also influence disease rates. When studies of individuals are conducted, the data lead to the conclusion that cigarette smoking is a major cause of disease and death in each of the four U.S. racial/ethnic minority groups studied in this report. These studies reveal few major differences in the risk ratios for various diseases. Limited epidemiological and biological data suggest that African Americans may be at an especially high level of risk for lung cancer. Although further research could clarify the nature of the interrelationships between cigarette smoking, other risk factors, potential modifying factors, racial/ethnic group membership, and various disease outcomes, it is clear that reducing tobacco use in each of the nation's racial/ethnic groups will reduce the incidence and mortality from several of the nation's leading causes of death and is a major public health goal to pursue.

Effects of Exposure to Environmental Tobacco Smoke

Environmental tobacco smoke (ETS) is the mixture of sidestream smoke and exhaled mainstream smoke that is produced by active smokers and then involuntarily inhaled by nonsmokers. Over the past decade, the adverse effects of ETS have been reported in the literature. The 1986 Surgeon General's report on smoking and health (USDHHS 1986a) concluded that the inhalation of ETS (labeled "involuntary smoking" in that report) is a cause of diseases, including lung cancer, in healthy nonsmokers and that the children of parents who smoke are more likely than the children of nonsmoking parents to have respiratory infections, respiratory symptoms, and abnormal maturation of lung function. Similar conclusions were also reached in 1986 by a committee of the National Research Council (1986). More recently, the U.S. Environmental Protection Agency (1992) assessed the risks associated with ETS, and the results reaffirmed that ETS is carcinogenic and that it exacerbates and may even cause childhood asthma. To date, racial/ethnic group differences in the adverse effects of ETS have not been investigated, although a number of studies have investigated racial/ethnic group differences in the level of exposure to ETS and in people's reactions to ETS.

Overpeck and Moss (1991) examined patterns of exposure to ETS among children five years of age and younger included in the 1988 NHIS and found that exposure varied by race/ethnicity and socioeconomic status (Table 12). African American children were the most likely to be exposed to ETS, whereas Hispanic children were the least likely to be exposed to ETS. Moreover, in the CARDIA (Coronary Artery Risk Development in [Young] Adults) study, the prevalence of exposure to ETS was significantly higher among African Americans (32 percent) than among whites (24 percent) (Wagenknecht et al. 1993). Overall, 28 percent of individuals 18–30 years of age were exposed to ETS, as detected by a serum cotinine level of 2–13 ng/mL. Adult survey data from the 1992 California Tobacco Survey show that Hispanics (21.3 percent) were most likely to report working around a cigarette smoker within the two weeks before the survey (Pierce et al. 1994). Asian Americans (13.2 percent) and African Americans (12.8 percent) reported being exposed to ETS at work in lower proportions than whites (17.9 percent). Data from the 1988 NHIS (CDC 1992) show that 40.3 percent of employed adults reported that cigarette smoking was allowed in their place of employment. The percentages of persons who reported experiencing discomfort caused by ETS exposure at work did not differ significantly by racial/ethnic group. In a 1992–1993 study of U.S. adults who worked indoors, Asian Americans and Pacific Islanders (51.4 percent) were the most likely and African Americans (43.3 percent) were the least likely to work under a completely smoke-free ETS policy (Gerlach et al. 1997). Since most studies suggest that differences exist in the ETS exposure of various racial/ethnic groups, studies to monitor the health effects of this exposure are needed.

Table 12. Exposure to household smoke among children 5 years of age and younger and percentage distribution, by level of exposure since birth and selected characteristics, United States, 1988

Characteristic	Number of children (in thousands)†	Percentage distribution*				
				Exposed since birth		
		Total	Not exposed since birth	Total‡	Current smoker in household	Former smoker in household
All children§	19,019	100.0	51.1 (0.9)	48.9 (0.9)	42.4 (0.9)	6.1 (0.4)
Ethnicity						
African American	2,759	100.0	41.5 (2.4)	58.5 (2.4)	51.3 (2.4)	6.7 (1.2)
White	15,575	100.0	51.9 (1.0)	48.1 (1.0)	41.6 (1.0)	6.1 (0.4)
Hispanic origin						
Non-Hispanic	16,923	100.0	50.4 (1.0)	49.6 (1.0)	43.2 (1.0)	6.0 (0.4)
Hispanic	2,096	100.0	56.4 (2.6)	43.6 (2.6)	35.8 (2.5)	6.9 (1.2)
Mexican American	1,006	100.0	60.7 (4.1)	39.3 (4.1)	31.8 (3.8)	6.5 (1.5)
Annual household income						
<$10,000	2,685	100.0	33.4 (2.1)	66.6 (2.1)	57.7 (2.3)	8.7 (1.1)
$10,000–$24,999	5,436	100.0	44.3 (1.5)	55.7 (1.5)	48.8 (1.6)	6.3 (0.7)
$25,000–$39,999	4,871	100.0	55.9 (1.7)	44.1 (1.7)	38.3 (1.6)	5.4 (0.7)
≥$40,000	4,149	100.0	65.7 (1.8)	34.3 (1.8)	29.5 (1.5)	4.6 (0.9)
Poverty status△						
In poverty	3,376	100.0	36.4 (2.1)	63.6 (2.1)	55.7 (2.3)	7.6 (1.0)
Not in poverty	14,582	100.0	54.8 (1.0)	45.2 (1.0)	39.2 (1.0)	5.6 (0.4)
Mother's education						
<12 years	3,279	100.0	33.3 (2.2)	66.7 (2.2)	61.2 (2.1)	5.1 (0.8)
12 years	8,014	100.0	44.5 (1.4)	55.5 (1.4)	47.9 (1.4)	7.3 (0.6)
>12 years	7,505	100.0	66.3 (1.2)	33.7 (1.2)	27.6 (1.1)	5.4 (0.6)
Place of residence						
Metropolitan statistical area	14,550	100.0	51.5 (1.0)	48.5 (1.0)	42.2 (1.1)	5.9 (0.4)
Central city	5,994	100.0	49.4 (1.4)	50.6 (1.4)	43.6 (1.5)	6.3 (0.6)
Not central city	8,556	100.0	52.9 (1.4)	47.1 (1.4)	41.1 (1.4)	5.6 (0.6)
Not metropolitan statistical area	4,469	100.0	49.7 (1.9)	50.3 (1.9)	43.1 (1.7)	6.8 (0.8)

*Figures in parentheses are standard errors of estimates.
†Excludes children whose exposure status is unknown.
‡Includes children exposed since birth whose period of exposure is unknown.
§Includes all other ethnicities, unknown household income, unknown poverty status, unknown education of mother, and unknown assessed health status.
△Poverty status determined in the National Health Interview Survey by family size, number of children, and household income by using 1987 poverty levels defined by the U.S. Bureau of the Census.
Source: Adapted from Overpeck and Moss 1991.

Effects of Smokeless Tobacco Use

Smokeless tobacco refers to moist oral snuff, dry oral and nasal snuff, and chewing tobacco. Smokeless tobacco is commonly used by youths, particularly those in rural areas, and it is highly addictive (USDHHS 1986b; Boyd and Glover 1989). Among the adverse health effects of smokeless tobacco use are oral cancer, oral leukoplakia (white mouth lesions that may be precancerous), gingival recession, periodontal diseases, elevated blood pressure, and increased risk for cardiovascular disease (NCI 1992; USDHHS 1994; Bolinder et al. 1994).

Few studies have examined the adverse health effects of smokeless tobacco use in racial/ethnic minority populations, and the research that has been conducted has been limited in several ways: (1) population-based, case-control studies rarely have sufficient numbers of racial/ethnic group members to allow group-specific analyses for groups other than African Americans (Blot et al. 1988; Day et al. 1993); (2) because the use of smokeless tobacco and associated health effects are relatively rare in most racial/ethnic groups, the feasibility of conducting prospective investigations is limited; and (3) smokeless tobacco users often report current or past use of other substances, such as cigarettes and alcohol, that are risk factors for health effects also associated with smokeless tobacco use, such as oral cancer (Blot et al. 1988; Mattson and Winn 1989). These multiple risk factors complicate or preclude analysis of the independent effects of smokeless tobacco use.

The valid data that are available, however, indicate that for men, the prevalence of smokeless tobacco use is highest among American Indians, Alaska Natives, and whites; for women, the prevalence is highest among American Indians, Alaska Natives, and African Americans (CDC 1993c). Data for 1989–1991 show that rates of death from cancers of the lip, oral cavity, and pharynx have been higher among African American men (7.8 per 100,000) than among Puerto Rican men (3.9 per 100,000), Asian American and Pacific Islander men (3.4 per 100,000), and white men (3.2 per 100,000) (Table 2) (NCHS, public use data tapes, 1989–1991; U.S. Bureau of the Census 1993).

In a case-control study, Winn and colleagues (1981) examined the estimated relative risk of oral and pharyngeal cancer associated with snuff-dipping among African American and white women in the southern United States. Although the relative risk was higher among white women (4.2) than among African American women (1.5), white women had dipped snuff for significantly longer periods and had consumed more snuff per week than African American women had. The relative risk for cancers of the gum and buccal mucosa increased with longer duration of snuff use, but this analysis was not conducted separately for African Americans and for whites.

A few studies of the health effects associated with smokeless tobacco use have been conducted among American Indian and Alaska Native populations. In a study of Navajo youths aged 14–19 years in New Mexico (Wolfe and Carlos 1987), 64 percent of the teenagers used smokeless tobacco products. Oral leukoplakia was found in 26 percent of smokeless tobacco users, representing a ninefold increase in risk when these youths were compared with those who did not use smokeless tobacco. The estimated relative risk of leukoplakia increased with duration and frequency of smokeless tobacco use. The investigators observed no apparent differences between users and nonusers of smokeless tobacco regarding gingival bleeding, calculus accumulation, or the extent or severity of gingival recession or loss of periodontal attachment.

In a survey of students in grades 7–12 attending schools on the Rosebud Sioux Reservation in South Dakota, more than one-third of the students reported regularly using smokeless tobacco (CDC 1988). Of these regular users, 37 percent had oral lesions (i.e., any white or red wrinkled area in the mouth or buccal mucosa). The students with oral lesions had used smokeless tobacco for a mean of 3.4 years, 6.6 times per day, and they had held each dip or chew for an average of 40 minutes. Students who used smokeless tobacco but did not have lesions had used the product for a mean of 2.5 years, 2.9 times per day, and they had held each dip or chew for an average of 30 minutes. This suggests a possible relationship between duration and intensity of smokeless tobacco use and the occurrence of oral lesions. The prevalence of oral lesions among nonusers of smokeless tobacco was not reported.

The 1986–1987 National Survey of Oral Health in U.S. School Children conducted oral clinical examinations on 17,027 children aged 12–17 years who provided information on their use of various tobacco products (Tomar et al. 1997). Smokeless tobacco lesions (defined by the authors as slight to heavy

wrinkling of the oral mucosa) were more common among white (2.0 percent) than among African American (0.2 percent) or Hispanic (0.8 percent) school children. In white males, the strongest correlates of lesions were, in order, current snuff use and current chewing tobacco use. Lesions were more common with increasing duration and frequency of smokeless tobacco use. Because of small sample sizes, analyses were not conducted on data for other racial/ethnic groups.

Nicotine Addiction and Racial/Ethnic Differences

Most smokers have difficulty quitting because they are addicted to nicotine (USDHHS 1988). An understanding of the role of nicotine addiction in determining smoking behavior could help clarify racial/ethnic differences in tobacco use and facilitate smoking cessation treatment. Nicotine addiction was reviewed extensively in the 1988 Surgeon General's report on smoking and health (USDHHS 1988). Concepts of addiction also have been reviewed in subsequent Surgeon General's reports (USDHHS 1989b, 1994). However, relatively little research has been conducted on racial/ethnic minority differences in nicotine addiction. This section provides a brief review of nicotine addiction and discusses the limited data on racial/ethnic differences and nicotine addiction.

Nature of Addiction

In the broadest sense, addiction (often used interchangeably with dependence) indicates a loss of control over drug-taking behavior. The World Health Organization describes drug dependence as "a behavioral pattern in which the use of a given psychoactive drug is given a sharply higher priority over other behaviors which once had a significantly higher value" (Edwards et al. 1982). In other words, drug use controls one's behavior to an extent considered detrimental to the individual or to society.

The criteria for drug dependence, described in the 1988 Surgeon General's report on smoking and health (Table 13) (USDHHS 1988), include highly controlled or compulsive use of a drug, the use of a drug that produces psychoactive effects, and evidence that drug-taking behavior is reinforced by the effects of the drug. Other criteria for drug dependence have been developed by the American Psychiatric Association [APA] (1994) for the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV™)* (Table 14). These criteria are quite specific and useful in diagnosing drug dependence in individual patients.

Pharmacologic Factors in Nicotine Addiction

Nicotine addiction, like all drug addictions, is a complex process involving the interplay of pharmacology, learned or conditioned factors, personality, social setting, and genetics (USDHHS 1988, 1994; Benowitz 1992a). The pharmacologic reasons for drug use include an enhancement of one's mood or functioning. Drugs produce such effects either directly or by relieving withdrawal symptoms. The pharmacologic factors involved in nicotine addiction work in several ways. For example, positive effects reported after smoking tobacco include pleasure, arousal, and relaxation as well as improved attention, reaction time, and performance of certain tasks. In addition, cigarette smoking has been cited as effective in relieving aversive emotional states, including reducing anxiety or stress, relieving hunger and preventing weight gain, and relieving nicotine withdrawal symptoms (Table 15) (Benowitz 1992a).

The pharmacology of nicotine addiction can be discussed in relation to several processes: (1) absorption, distribution, and elimination of nicotine in the body (pharmacokinetics); (2) pharmacologic effects of nicotine on target organs (pharmacodynamics); and (3) translation of pharmacologic effects into behavior. These processes are reviewed in the following sections, and racial/ethnic differences are discussed when information is available.

Absorption, Distribution, and Elimination of Nicotine in the Body

Nicotine from tobacco smoke is absorbed rapidly across the lungs' alveolar membranes and into the systemic circulation (Benowitz 1990). Following absorption from the lung, concentrations of nicotine in the blood rise quickly and peak at the completion of smoking. Concentrations of nicotine in arterial blood leaving the lungs and heart are several times higher than those measured in venous blood (Henningfield

Table 13. Criteria for drug dependence

Primary criteria
Highly controlled or compulsive use
Psychoactive effects
Drug-reinforced behavior
Additional criteria
Addictive behavior often involves—
stereotypic patterns of use
use despite harmful effects
relapse following abstinence
recurrent drug cravings
Dependence-producing drugs often produce—
tolerance
physical dependence
pleasant (euphoric) effects

Source: Adapted from U.S. Department of Health and Human Services 1988.

et al. 1993). Within 10 to 19 seconds after the start of a puff, nicotine is delivered to the brain. Rapid delivery of high concentrations of nicotine to the brain provides the possibility for rapid behavioral reinforcement from smoking and allows the smoker to control the concentration of nicotine in the brain and, hence, to modulate the pharmacologic effects of nicotine.

In contrast, the absorption of nicotine from smokeless tobacco is gradual, with blood levels peaking at the end of chewing tobacco or using snuff (Benowitz et al. 1988). Buccal-oral absorption results in a gradual increase in concentrations of nicotine in the brain, with relatively little arterial-venous disequilibrium. This pattern of absorption may provide a less intense pharmacologic reinforcement than that produced by smoke inhalation but is sufficient to produce addiction.

The level of nicotine in the body is determined by the balance of nicotine intake from tobacco and the rate of nicotine elimination from the body. Nicotine is eliminated primarily by hepatic metabolism, with a small amount (5–10 percent) excreted unchanged in the urine. The primary metabolite of nicotine is cotinine, which has been used as a measure of nicotine exposure (Benowitz 1996). Keenan and colleagues (1994, 1995) recently published preliminary data consistent with the hypothesis that cotinine has some psychoactive properties. These effects do not appear to be mediated by nicotine receptor agonism, but could play some role in nicotine addiction. The rate of metabolizing nicotine varies considerably from person to person (Benowitz et al. 1982). A person who metabolizes nicotine slowly would not need to take in as much nicotine to achieve a particular level of nicotine in the body as a person who metabolizes nicotine more rapidly. The level of nicotine in the body appears to be positively correlated with the degree of nicotine dependence and negatively correlated with the likelihood of successful cessation therapy (USDHHS 1988; Pomerleau et al. 1990; Sutherland et al. 1992).

Theoretically, racial/ethnic differences in the absorption, distribution, or elimination of nicotine could influence the likelihood of developing nicotine dependence (see Racial/Ethnic Differences in Nicotine Metabolites later in this chapter for further discussion of this topic).

Pharmacodynamics of Nicotine

Nicotine acts on nicotinic cholinergic receptors in the brain and other organs of the body, enhancing the release of neurotransmitters such as acetylcholine, norepinephrine, dopamine, beta-endorphin, and serotonin (USDHHS 1988). The physiologic consequences of nicotine intake include behavioral arousal and sympathetic neural activation (Table 15) (Benowitz 1992a). The release of specific neurotransmitters has been speculatively linked to the various reinforcing effects of nicotine (Pomerleau and Pomerleau 1984). For example, the enhanced release of dopamine and norepinephrine may be associated with pleasure as well as appetite suppression, the latter of which may contribute to lower body weight. The release of acetylcholine may be associated with improved performance of behavioral tasks and improved memory, whereas the release of beta-endorphin may be associated with reduced anxiety and tension.

Although smokers give different explanations for smoking, most agree that smoking produces arousal, particularly with the first few cigarettes of the day, and paradoxically, smoking can also be calming or relaxing, especially in stressful situations (Pomerleau and Pomerleau 1984; Benowitz 1992a). Consistent with reports of arousal, the smoking of cigarettes or the administration of nicotine is followed by electroencephalographic desynchronization, with an upward shift in the brain's dominant alpha frequency and decreased total alpha and theta power (Pickworth et al. 1989).

Table 14. American Psychiatric Association diagnostic criteria for substance dependence

A maladaptive pattern of substance use, leading to clinically significant impairment or distress, as manifested by three or more of the following consequences, occurring at any time in the same 12-month period:

Tolerance, as defined by either—

need for markedly increased amounts of the substance to achieve intoxication or desired effect or markedly diminished effect with continued use of the same amount of the substance.

Withdrawal, as manifested by either—

the characteristic withdrawal syndrome* for the substance or
the same (or a closely related) substance being taken to relieve or avoid withdrawal symptoms.

Consumption of the substance in larger amounts or over a longer period than was intended.

Having a persistent desire to cut down or control substance use or unsuccessfully trying to do so.

Spending a great deal of time in activities necessary to obtain the substance (e.g., visiting multiple doctors or driving long distances), use the substance (e.g., chain-smoking), or recover from its effects.

Giving up or reducing important social, occupational, or recreational activities because of substance use.

Continuing to use the substance, despite the knowledge that one has a persistent or recurrent physical or psychological problem likely caused or exacerbated by the substance (e.g., current cocaine use despite recognition of cocaine-induced depression or continued drinking despite recognition that an ulcer was worsened by alcohol consumption).

*The characteristic withdrawal syndrome for nicotine refers to the daily use of nicotine for at least several weeks and abrupt cessation of nicotine use, or reduction in the amount of nicotine used, followed within 24 hours by four or more of the following signs: dysphoric or depressed mood; insomnia; irritability, frustration, or anger; anxiety; difficulty concentrating; restlessness; decreased heart rate; increased appetite or weight gain.
Source: Adapted from American Psychiatric Association 1994.

Several researchers have studied the effects of cigarette smoking and nicotine administration on the behavior of smokers who have abstained from tobacco use (abstinent smokers) (USDHHS 1988; Hughes et al. 1990; Warburton 1990; Le Houezec and Benowitz 1991; Heishman et al. 1994). Many of these studies have shown that nicotine restores tobacco-abstinence-related deficits in attention and short-term memory and decreases reaction time (Peeke and Peeke 1984; USDHHS 1988; Snyder et al. 1989; Snyder and Henningfield 1989; Warburton 1990; Levin 1992; Pritchard et al. 1992). Nicotine also may increase a person's vigilance in performing repetitive tasks and increase selective attention in abstinent smokers. The effects of nicotine on the cognitive functioning of nonsmokers have not been clearly identified (USDHHS 1988; Heishman et al. 1994). Smokers commonly report pleasure, mental stimulation, and reduction of stress after smoking a cigarette (McKennell 1970; Russell et al. 1974).

Cigarette smoking and nicotine also have sympathomimetic action, producing brief increases in blood pressure, heart rate, and cardiac output with cutaneous vasoconstriction (Benowitz 1988). Nicotine causes muscle relaxation by stimulating discharge of the Renshaw cells and pulmonary afferent nerves, which inhibit motor neuron activity and relax certain muscles. However, not all muscles are relaxed; increased electromyographic activity and tonicity of the large upper-back muscles (trapezius) have been observed after smoking (Fagerström and Götestam 1977).